Soft Target Terminal Ballistic Testing Standardization for the U.S. Military

Sponsored by: PM-Maneuver Ammunition Systems

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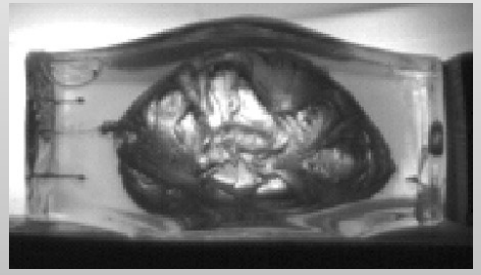
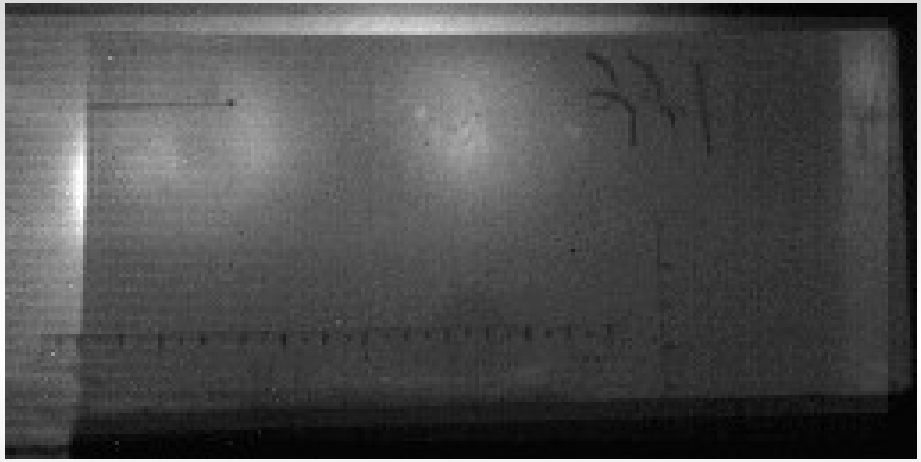
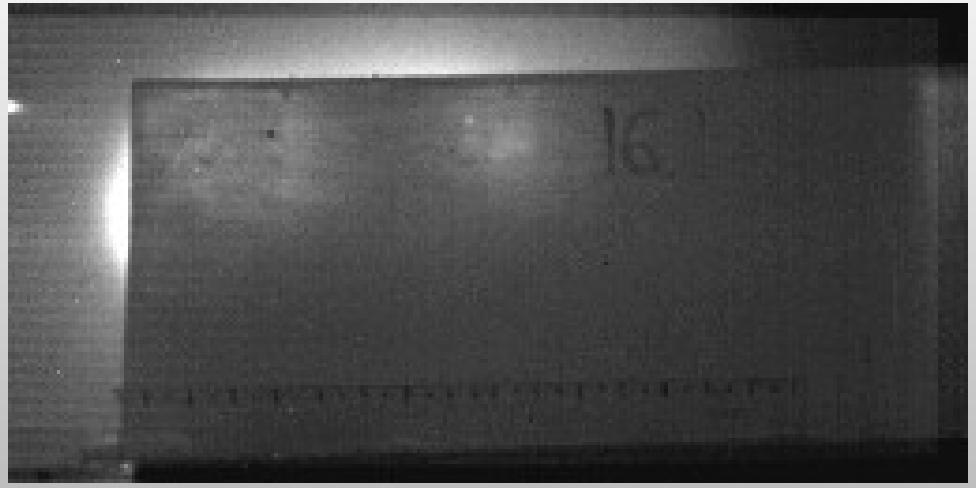


Ballistic Gelatin Impact Video

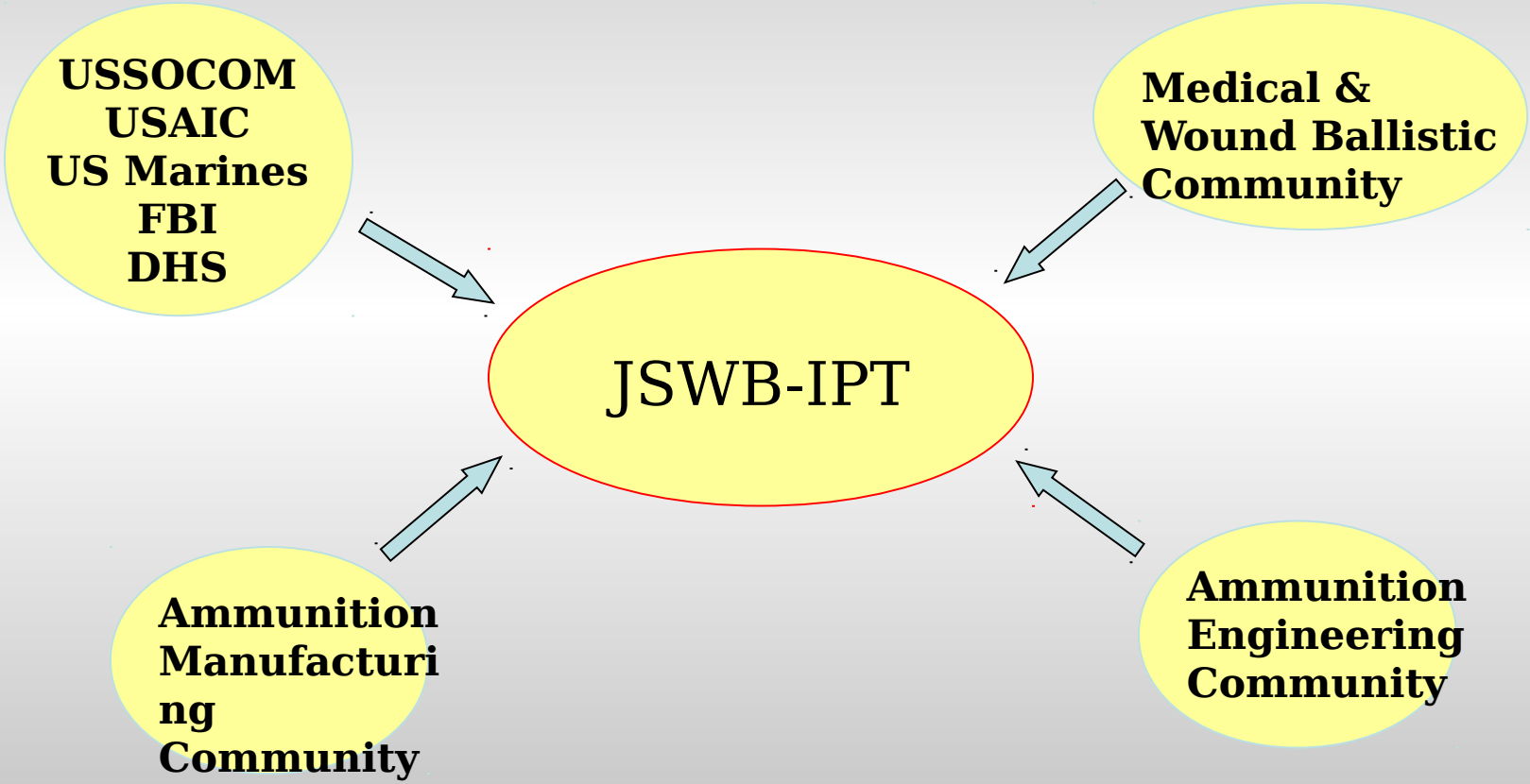
- 5.56mm
- 37-grain
- 2900 fps



- 5.56mm
- 77-grain
- 2500 fps



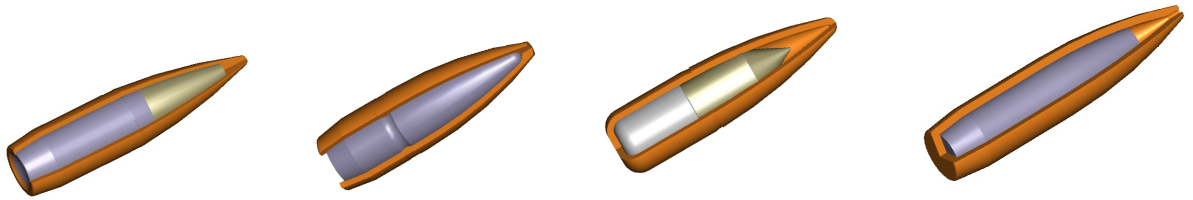
Joint Service Wound Ballistics IPT



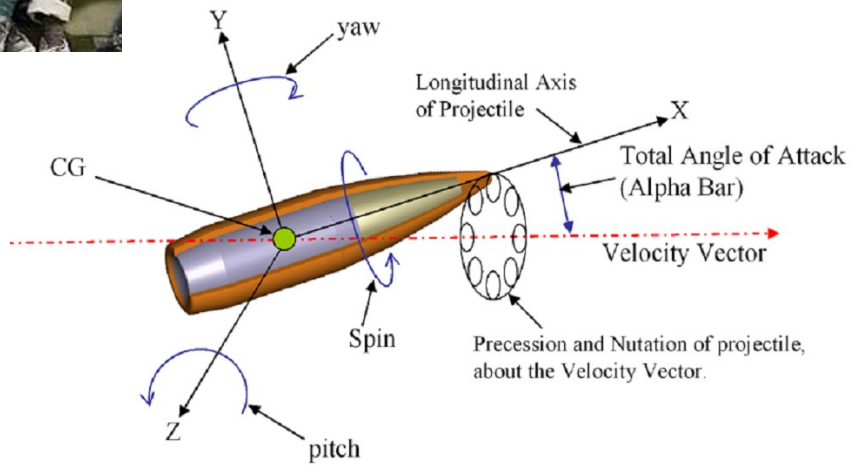
Charter Mission: To develop a standardized soft-target terminal ballistic test and evaluation procedure for small caliber weapon systems, based upon the use of ballistic gelatin.

Wound Ballistics Basics

- *"Controllable" Factor*
  - Projectile **Mass**
  - Projectile **Velocity**
  - Projectile **Configurati**



- *"Uncontrollable" Factors:*
  - **Target Composition**
  - **Angle of Attack at Impact**



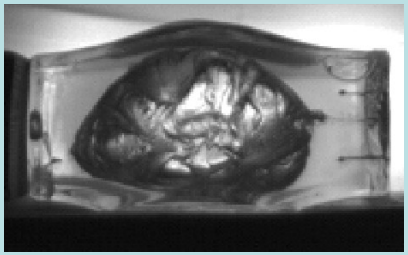
The Ballistic Gelatin Testing Process

Manufacturing

1

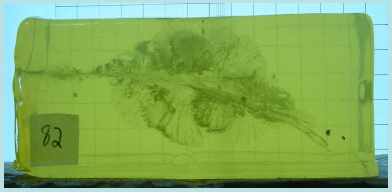
Shooting

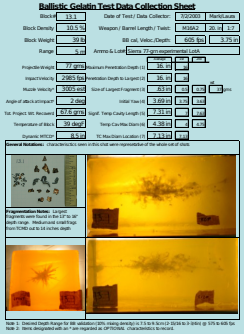
2



Dissection and Data Recovery

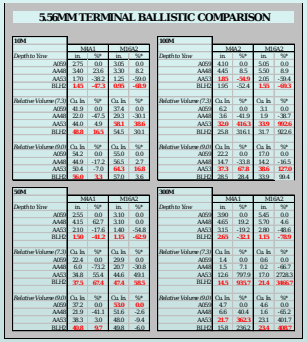
3





Comparison and Evaluation

4

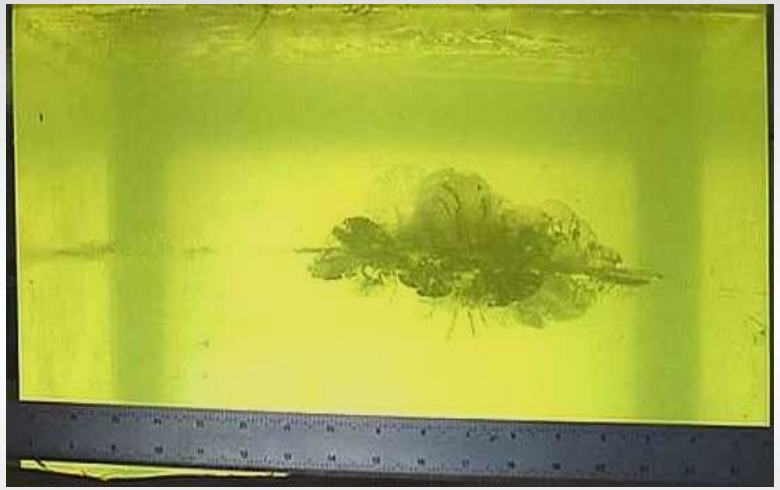


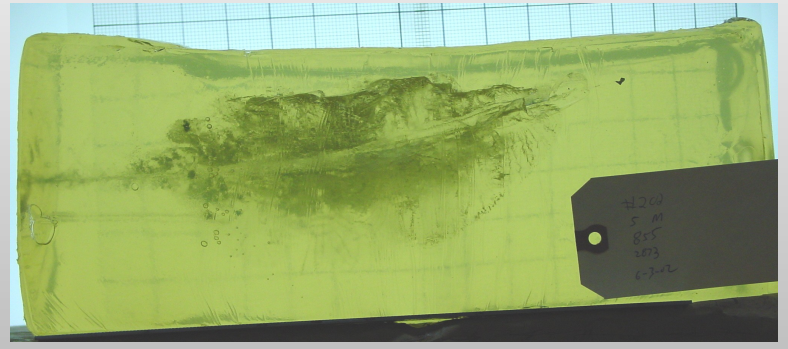
Why Standardize?

Both shots are M855, at 5 meters, into 10% gelatin, from M4s.

Note the general cavity location with respect to the impact point for each block.

Inconsistencies such as these can prevent the “joining” of data sets taken from different agencies.





Why Gelatin?

•Ballistic gelatin (when properly manufactured and validated) has been calibrated to impart retardation forces onto impacting projectiles similar to those experienced when impacting human body.

Pros

•Consistent, when manufactured to standard

•Homogenous simulant with similar material properties to select human tissue

•Transparent

•Many years of comparative data

•Multi-agency testing capability

Cons

•Human targets are not homogenous

•Gelatin is virtually incompressible, where certain human tissues are compressible (i.e. lung)

•Gelatin blocks do not simulate the interaction of the projectile with bones or cartilage.

•Labor intensive to manufacture, shoot and dissect.

Standardization Chronology

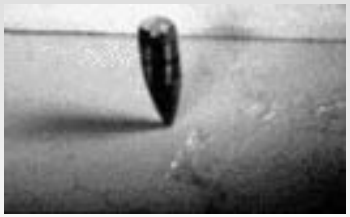
1. Complaints from field
2. Form Joint Service Wound Ballistics IPT
3. Develop **TESTING** standard based on IPT member experience
4. Conduct Round Robin testing to ensure consistency in the testing Standa
5. Conduct Engineering Study of small caliber rifle ammunition
    1. Baseline all candidates against M855
6. Develop **EVALUATION** Standard based on IPT member experience
7. Conduct comprehensive analysis of best performing ammunition
    1. Additional T&E as well as comparison to current methods of “Lethality” evaluation.
8. Determine the best direction for U.S. Military small caliber rifle ammunition to take in the present and near future

Where we are Today

Testing Phases

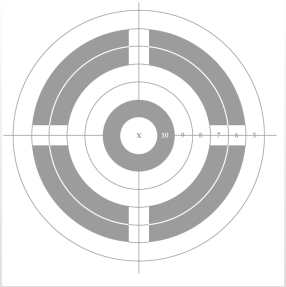
5 - 300m Bare Gelatin

300m Dispersion



R50 Steel Plate Penetration

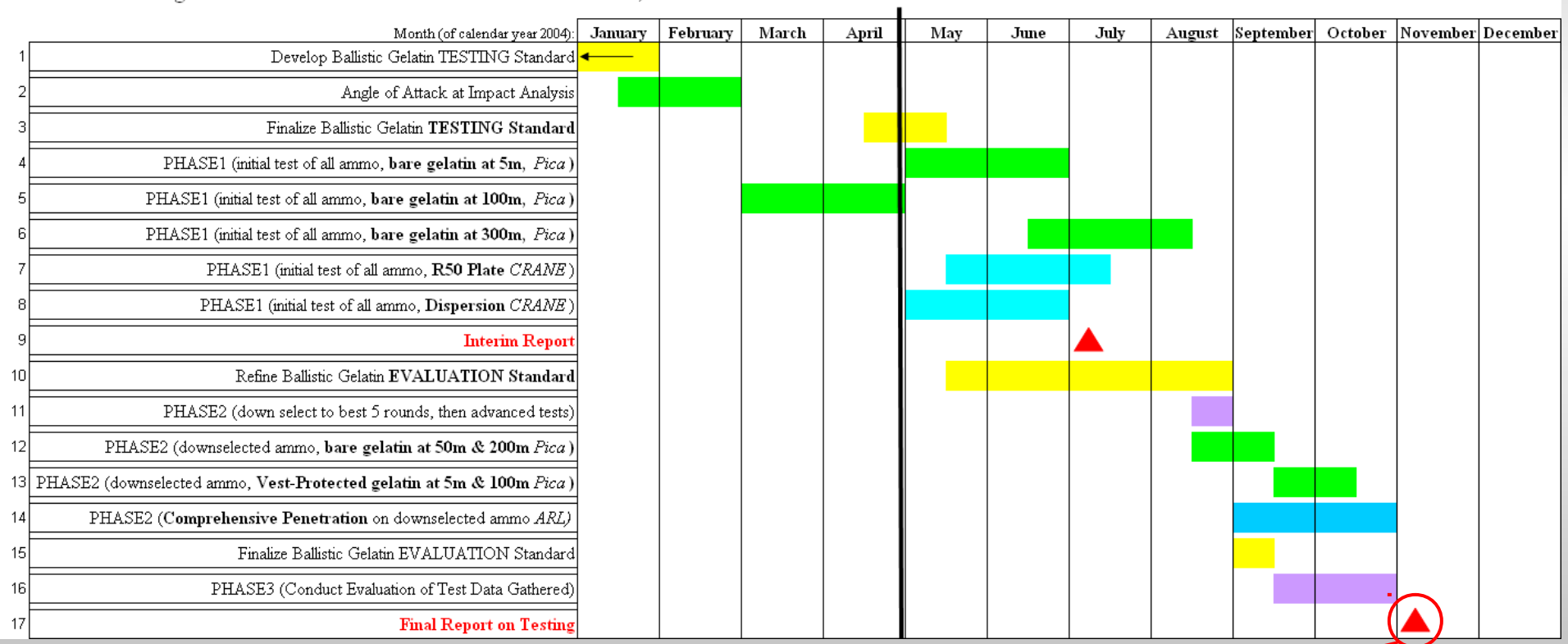
5 - 100m Vest-Protected Gelain



Comprehensive Steel Plate Penetration

Schedule

5.56mm Soft-Target Terminal Ballistic Evaluation Test Schedule, YEAR 2004


Month (of calendar year 2004):
January
February
March
April
May
June
July
August
September
October
November
December
1 Develop Ballistic Gelatin TESTING Standard
2 Angle of Attack at Impact Analysis
3 Finalize Ballistic Gelatin TESTING Standard
4 PHASE1 (initial test of all ammo, bare gelatin at 5m, Pica)
5 PHASE1 (initial test of all ammo, bare gelatin at 100m, Pica)
6 PHASE1 (initial test of all ammo, bare gelatin at 300m, Pica)
7 PHASE1 (initial test of all ammo, R50 Plate CRANE)
8 PHASE1 (initial test of all ammo, Dispersion CRANE)
9 Interim Report
10 Refine Ballistic Gelatin EVALUATION Standard
11 PHASE2 (down select to best 5 rounds, then advanced tests)
12 PHASE2 (downselected ammo, bare gelatin at 50m & 200m Pica)
13 PHASE2 (downselected ammo, Vest-Protected gelatin at 5m & 100m Pica)
14 PHASE2 (Comprehensive Penetration on downselected ammo ARL)
15 Finalize Ballistic Gelatin EVALUATION Standard
16 PHASE3 (Conduct Evaluation of Test Data Gathered)
17 Final Report on Testing

M&S Effort to follow

Brief the User

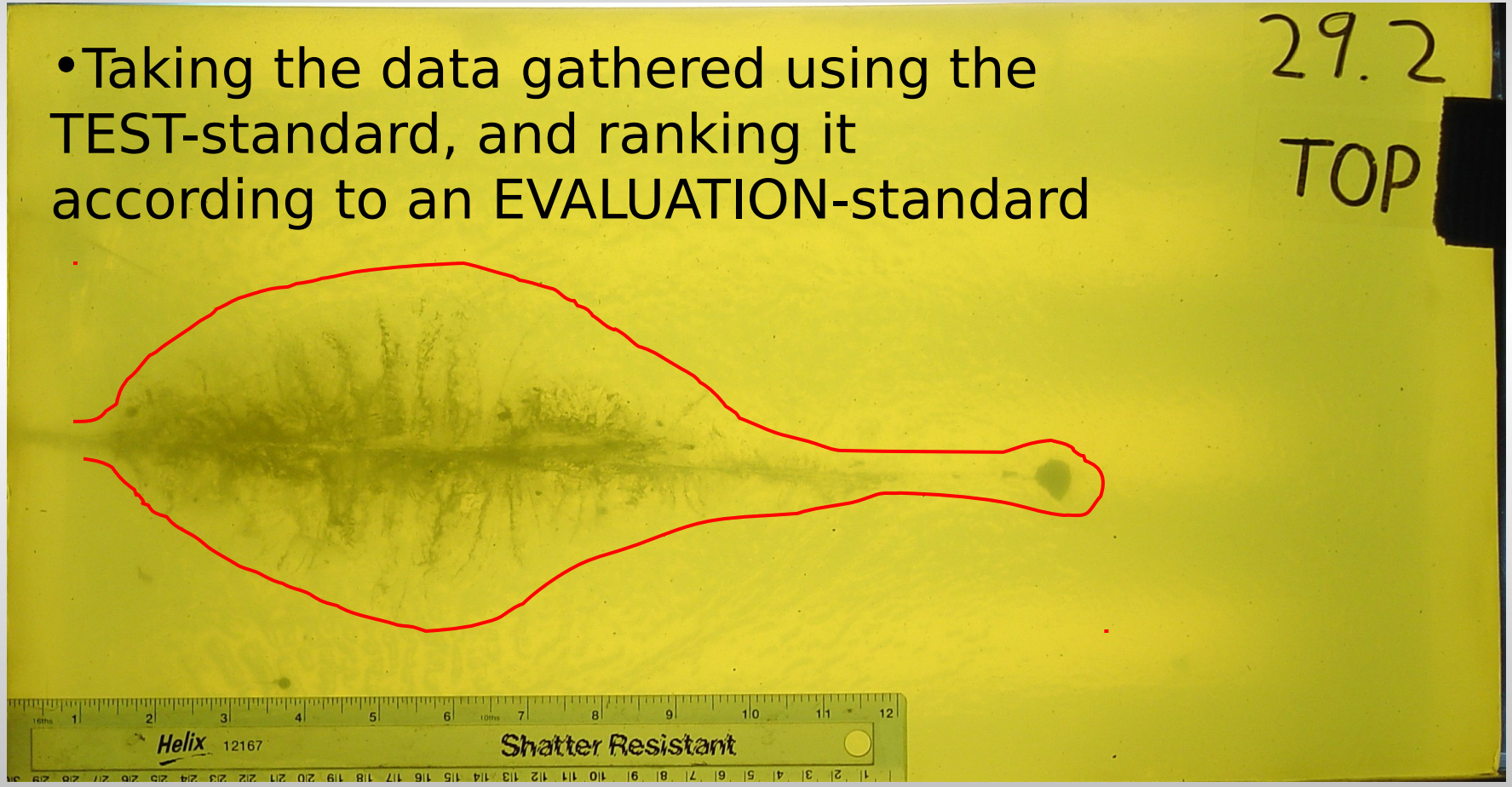
Evaluation Phase

Key Performance Parameters Chart (KPP)

KPP #	**Minimum Performance Requirement of individual characteristics seen in the gelatin block test**	**To maximize effectiveness of the projectile…**
1	Initial Yaw, or “onset of first significant yaw”, should be less than 3 inches from impact point.	•The closer IY is to the impact point the better.
2	Distance from impact point, to Temporary Cavity Maximum Diameter should be between 4 and 6 inches.	•The larger the TCD is (in the 4 to 6 inch range) the better.
3	Minimum penetration depth should be no less than 12 inches.	Deeper is better. (Note rule 2)
4	Fragmentation/Expansion is desirable. •Make note of the general pattern, mass-distribution, projectile mass recovered and fragment sizes. Fragments under 1/8” ignored. •NOTE: International Law must be observed as required	•The deeper the distributed pattern, the better. •Greater mass-percent recovery is better. •Larger wound channels are better
5	Consistency is desirable from shot-to-shot. •The Average standard deviation of any of the individual measured characteristics should be no more than 20%.	•The smaller the deviations, the better.

Evaluation Phase

- Taking the data gathered using the TEST-standard, and ranking it according to an EVALUATION-standard

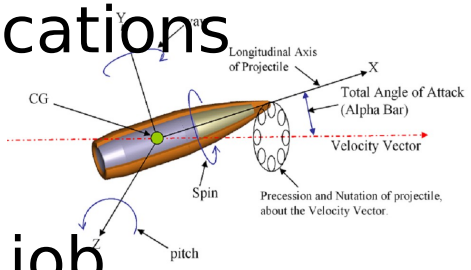


What makes the projectile an “effective” projectile in soft targets?

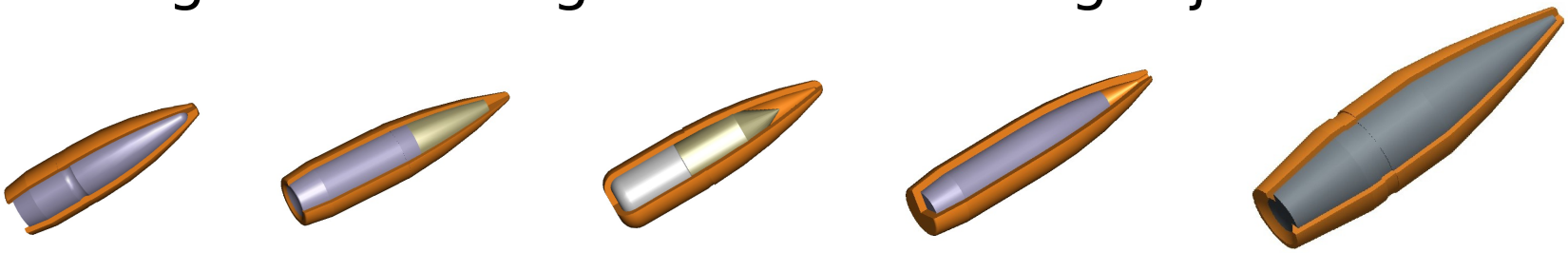
LESSON LEARNED TO DATE

- Barrel Length – Short vs. Lon

- Angle of Attack at Impact – CQB ramifications



- Configuration – Right tool for the right job



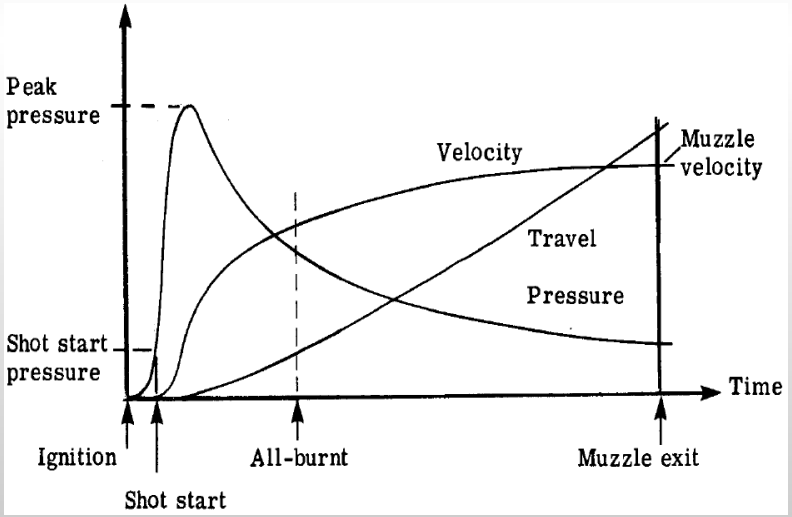
Barrel Length and Terminal Effects

Impact Velocity effects on fragmentation / expansion

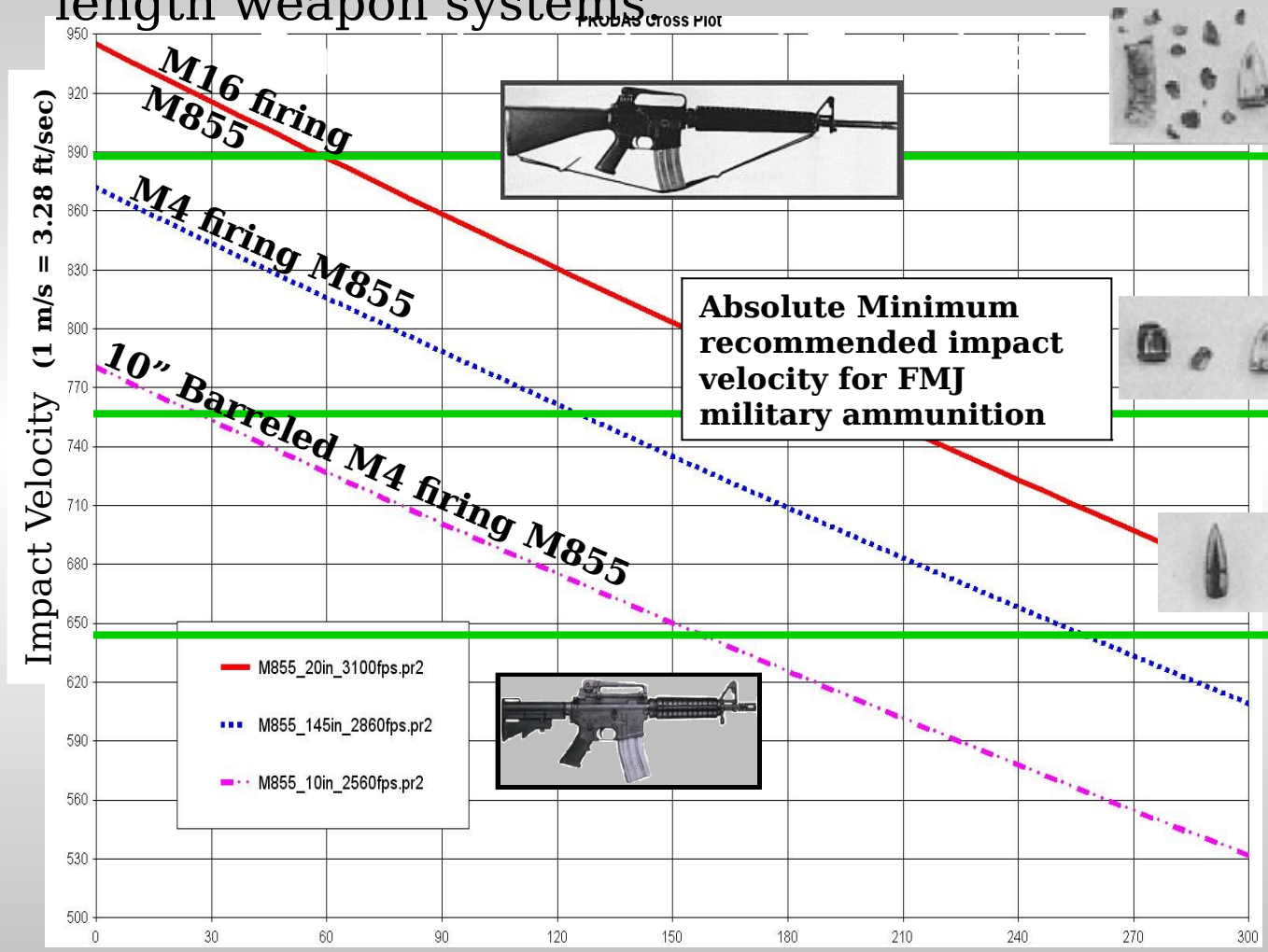
- Fragmentation or expansion of the projectile can increase the potential damage area in a human body.

- Ballistic testing can determine the impact velocity required to achieve significant fragmentation of a projectile.

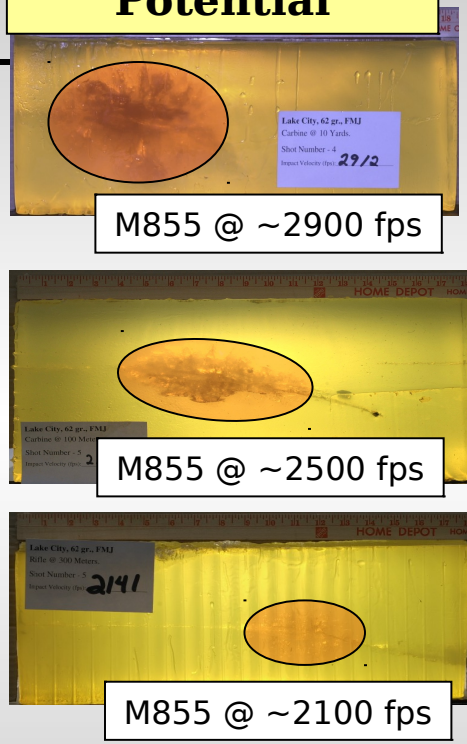
- Projectiles of different design configurations will fragment/expand at different impact velocities.



Below: Cross-Plot showing two different ammunition types, from two different barrels length weapon systems



Typical Soft Target Wound Potential

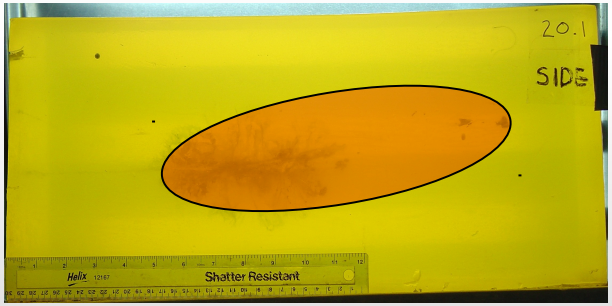


Note: NATO plate penetration spec of 600 meters for M855 may not be achievable with shorter barreled weapons

Caliber Comparison

All projectiles have “match” configurations, and all blocks were 100m from the

5.56mm OTM (77 grains)	6.8mm OTM (115 grains)	7.62mm OTM (175 grains)



Areas highlighted in RED represent the general damage done to the gelatin

Short Barrel Length; Pros & Cons

PROS:

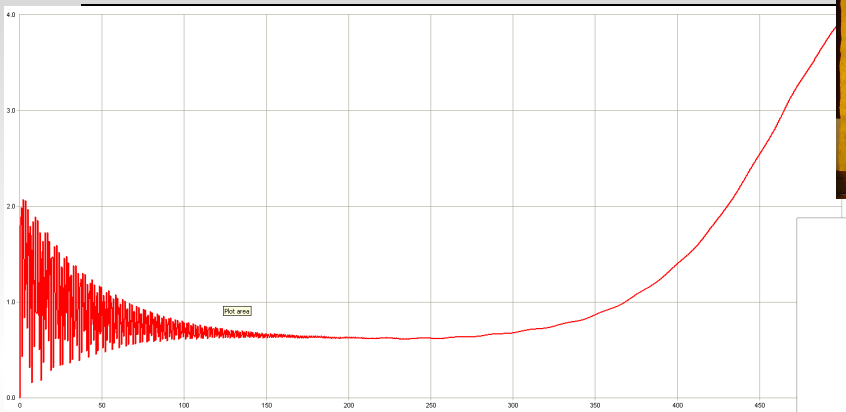
1. Lighter Weapon System Weight
2. More Maneuverable in MOUT / CQB areas

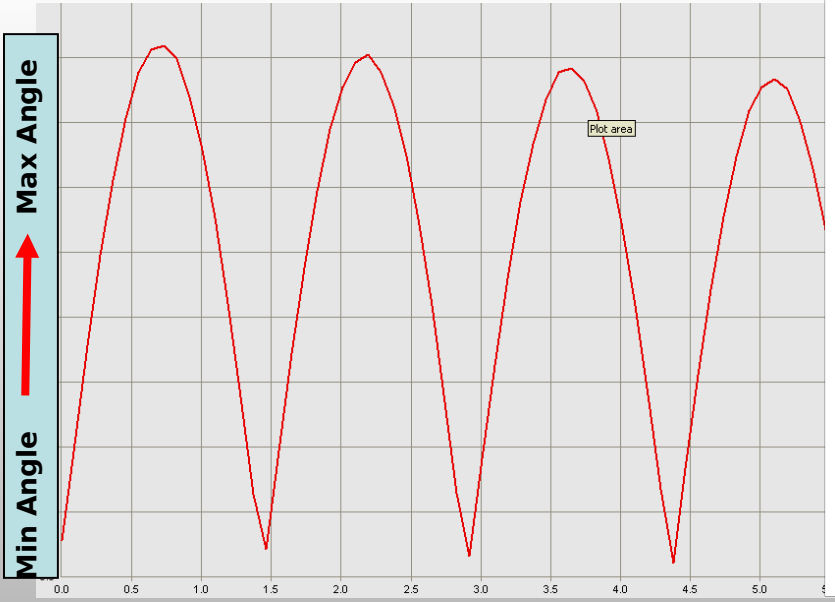
CONS:

1. Increased Muzzle Signature
2. Decreased Accuracy at Extended Ranges
3. Decreased Hard Target Penetration Performance
4. Decreased Soft Target Damage Potential at any range
5. Decreased Maximum Effective Range for any target, soft or hard
6. Increase of shot placement accuracy required

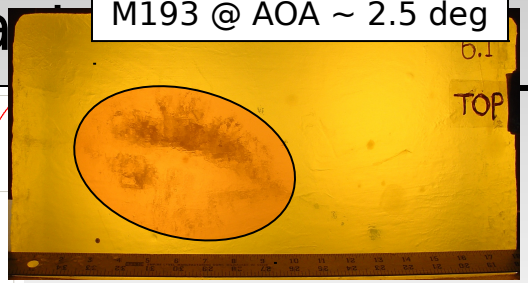
TRADE-OFFS, HOW MUCH OF EACH? DICTATED BY MISSION REQUIREMENTS?

Angle of Attack at Impa

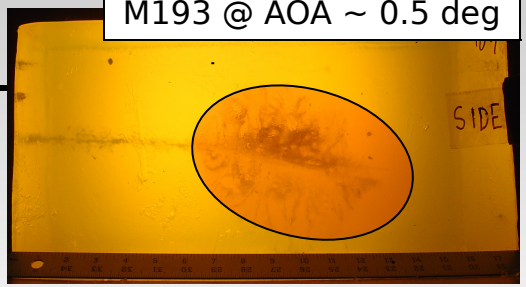


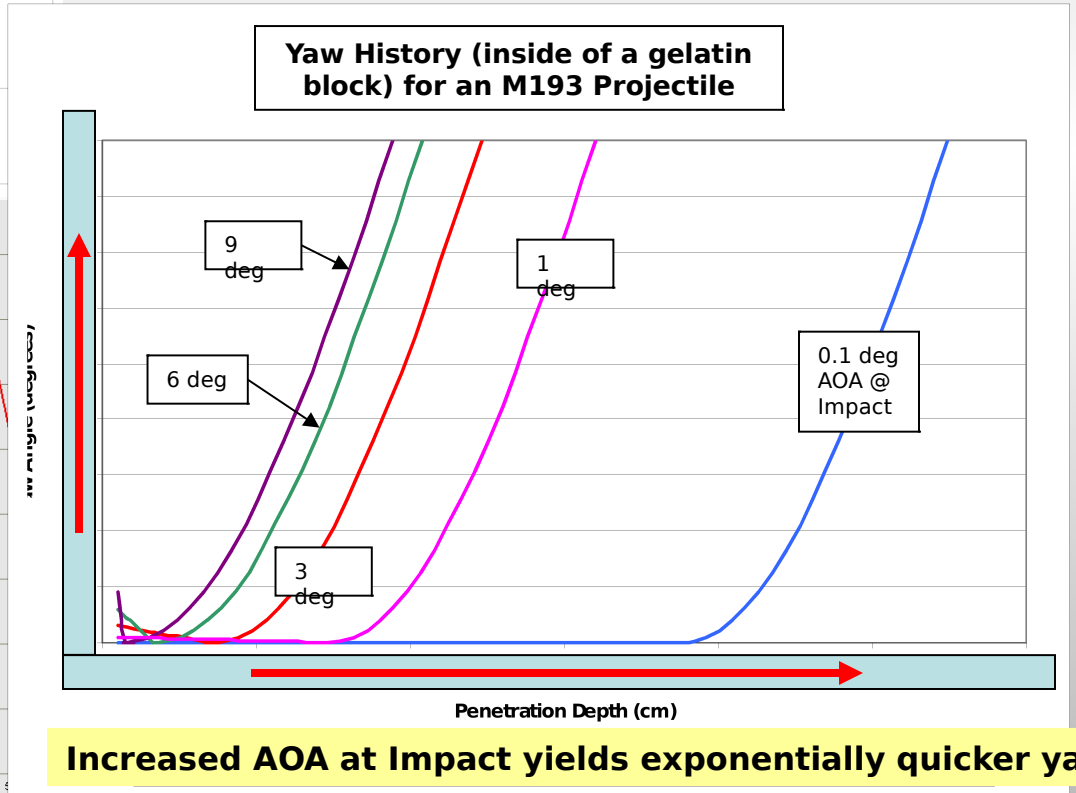


M193 @ AOA ~ 2.5 deg



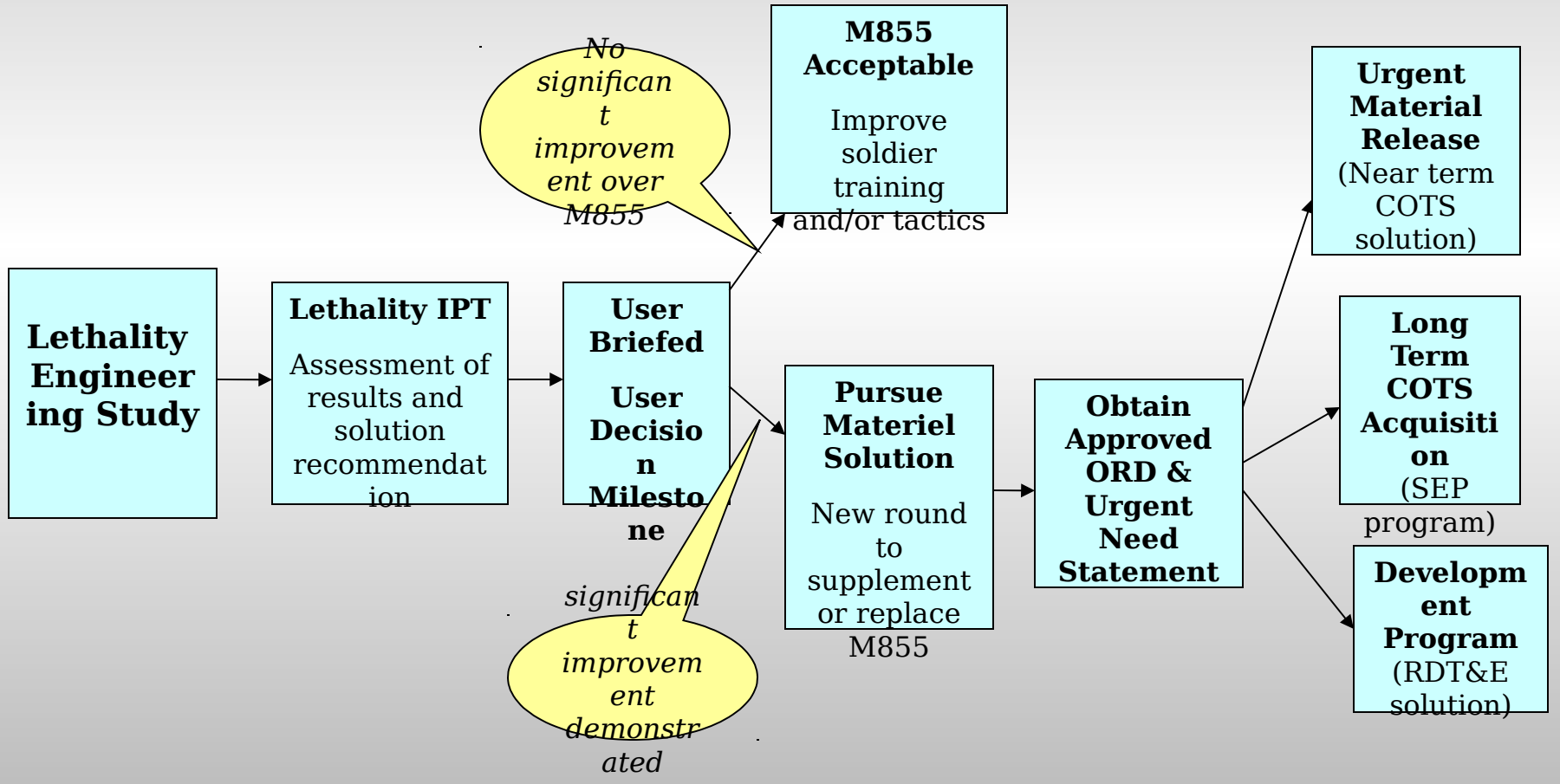
M193 @ AOA ~ 0.5 deg



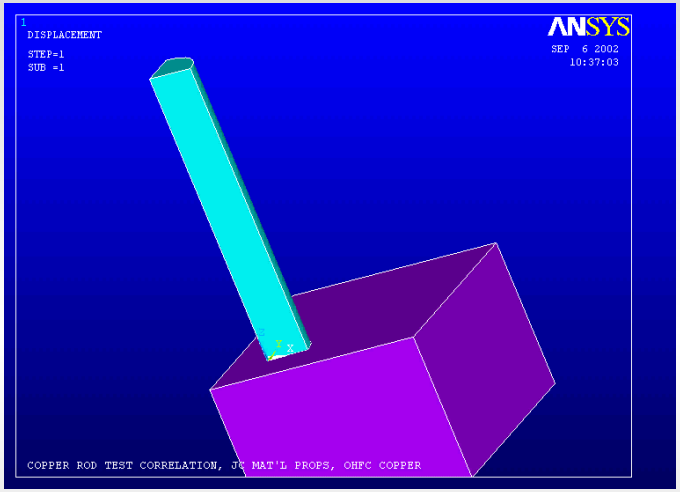


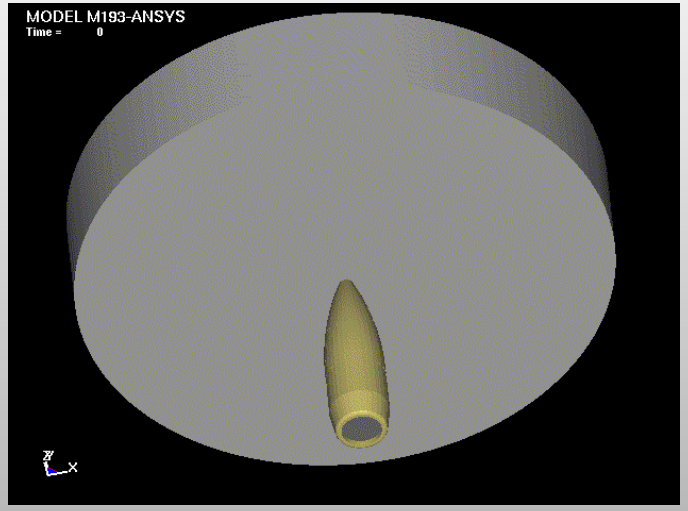
Increased AOA at Impact yields exponentially quicker yaw

The Path Forward

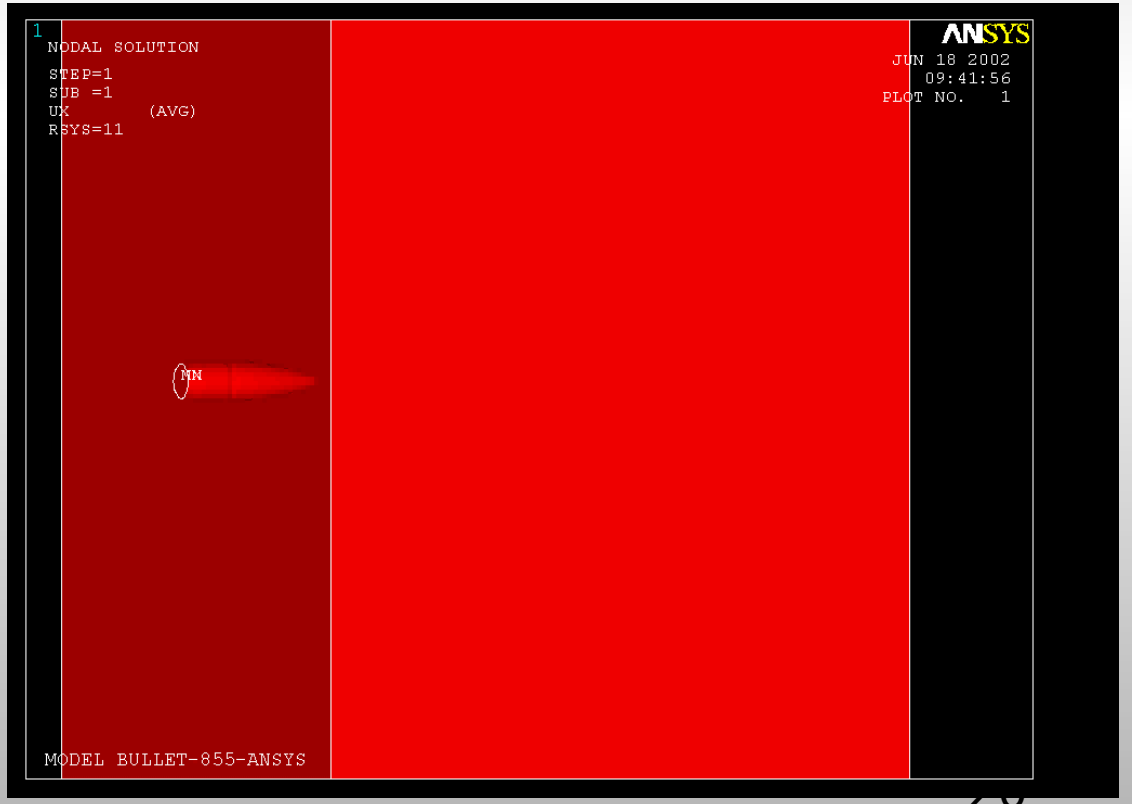


Modeling & Simulation of “Small-Cal” Impacts





1. Material Property Analysis
2. Material / Geometric Model Development
3. Simulation Development and Validation



Summary

- Barrel Length
- Angle of Attack
- Configuration
- Focused Testing Required
- Logistics vs. Ballistics
- Future Course of Action